Notes on the Plumages and Breeding Cycle of the Spotted Shag, Phalacrocorax (Stictocarbo) punctatus punctatus (Sparrman, 1786).

By E. G. TURBOTT, Auckland Museum.

The spotted shag, *Phalacrocorax (Stictocarbo) punctatus punctatus* (Sparrman, 1786), breeds in the Auckland area (Hauraki Gulf and west coast), Cook Strait, south-west Nelson, Banks Peninsula and Otago Peninsula. It is probably this form which breeds on islands off the coast of South Westland, although the identity of these birds is not yet certain. There were colonies formerly to the north of Auckland (Bay of Islands) and at Cape Kidnappers.

The representative form in the Stewart Island area, and apparently also in Foveaux Strait, is *P. punctatus steadi* (Oliver, 1930) (blue shag), and at the Chatham group *P. punctatus featherstoni* Buller, 1873 (Pitt Island shag). Oliver (1955) regards *Stictocarbo* as worthy of generic rank, and at the same time allots full specific rank to *P. punctatus featherstoni*, because of the absence of the white line on the side of the head and neck found in the other two. However, the relationship of *P. punctatus featherstoni* to these geographically separated forms is evidently so close that the present arrangement into three subspecies is a more satisfactory means of expressing their relationship.

P. punctatus is considered to be related elsewhere only to the red-footed cormorant, *P. gaimardi* (Lesson, 1828), of South America (Oliver, 1930a; Falla, 1932; Murphy, 1936). Oliver (1955) differs from this view, as he considers that *P. punctatus* and *P. gaimardi* show certain well-marked differences and are more likely to be derived separately from the pan-antarctic subgenus *Leucocarbo*. Thus, if Oliver's view is correct, similarities between *P. punctatus* and *P. gaimardi* are due to convergence.

All three forms keep entirely to coastal waters, and the breeding colonies are characteristically situated either on coastal cliffs providing ledges, often with overhanging rock faces, or in the interior of caves.

Information on the breeding and plumage sequences of the spotted shag is given by Falla (1932), based mainly upon material in the Auckland Museum collection from the Hauraki Gulf. It is now possible to modify Falla's descriptions in some particulars on the basis of additional field information and material added to the collections from the Auckland area. Stead (1932) also includes in his general account observations on plumages made at colonies on Banks Peninsula.

An earlier and valuable description is that of Potts (1873), whose detailed observations on breeding habits and plumages were made at Banks Peninsula colonies. A general account by Oliver (1930a; 1955, 2nd ed.) includes further field notes. In the present account, no attempt has been made to include information from the colonies other than those

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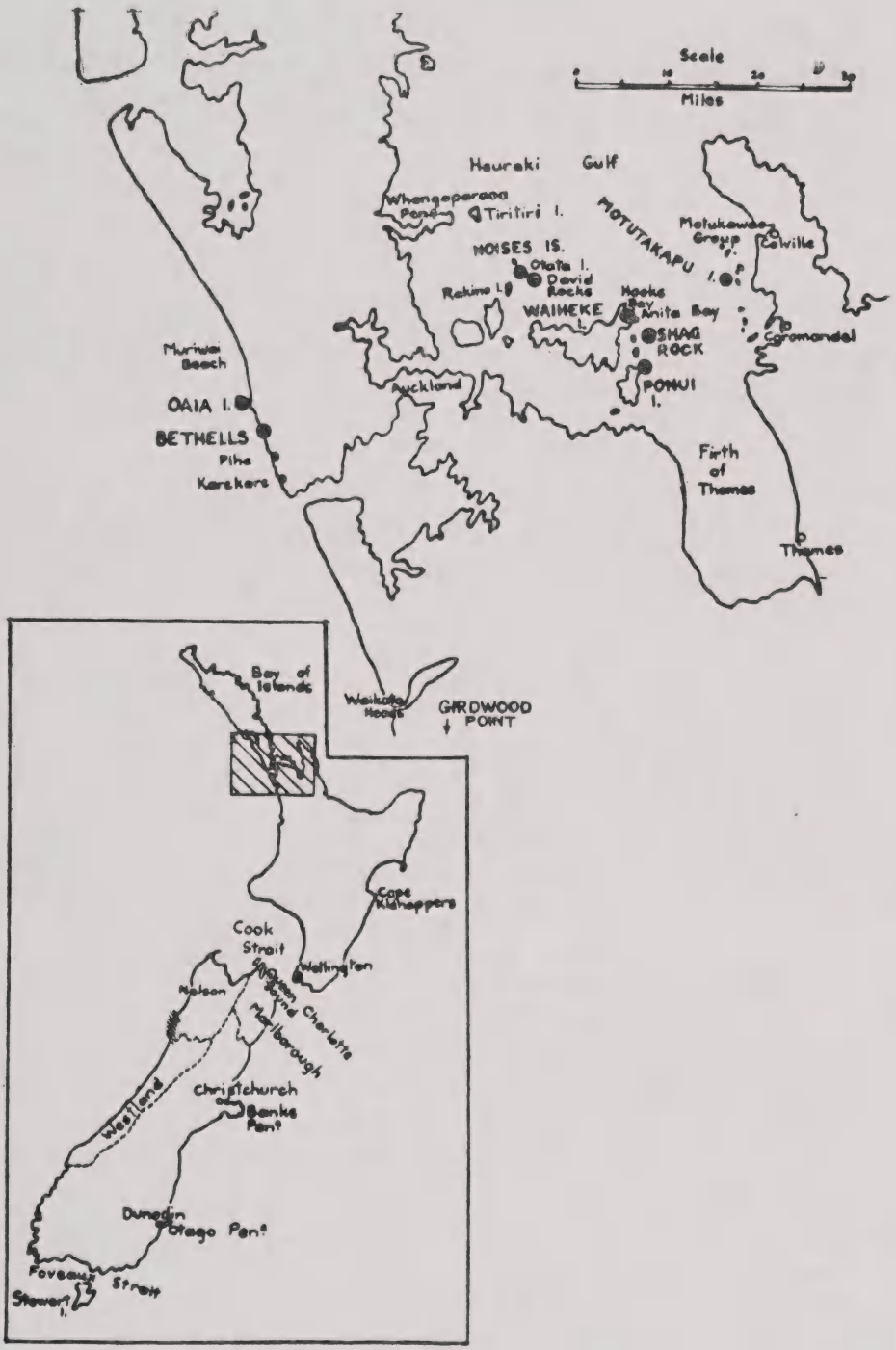

Text Fig. 1.
Location of breeding stations of the spotted shag.

in the Auckland area, except for a specimen from Banks Peninsula in the Dominion Museum, and one from Queen Charlotte Sound in the Auckland Museum collection, mentioned below.

I wish to express my thanks to Mr. O. Petersen and Mr. P. A. S. Stein for permission to incorporate their invaluable field records which form the basis of much of this paper. The fine series of photographs of several different pairs at successive stages taken by Mr. Petersen has enabled the plumage sequences to be very greatly clarified, and I am particularly indebted to him for permission to include them here.

Others who have kindly provided field notes are Miss N. Macdonald, Dr. R. A. Falla, Dr. W. R. B. Oliver, Mr. A. N. Breckon, Mr. J. C. Davenport and Mr. R. Moynihan.

NOTES ON COLONIES IN THE AUCKLAND AREA.

a. East Coast Colonies.

In 1910, according to Falla (1932), the spotted shag had an extensive distribution in the Hauraki Gulf, colonies being present at the following points: islands off Tiritiri, the Noises, Rakino Island, Waiheke Island, Shag Rock, and off Coromandel. After this date the colonies suffered severely from shooting, until in 1932 Falla had evidence of only one colony remaining on the western side of the Gulf. Buddle (1951) refers to the destruction of spotted shags which he saw practised some forty years earlier by shooting parties in the Hauraki Gulf. In a further comment, Falla (1940) states that "for many years the species suffered constant persecution in common with all other species." He adds: "If anything, it suffered more, for its habits are such that it showed no ability to move from an area of persecution and establish itself elsewhere." Measures for halting the process of extermination were taken in January, 1931, when an Order-in-Council giving total protection to the spotted shag came into force.

Falla (1932) considered that by 1932 only one colony remained. This colony, situated in a cave passing through the western shoulder of one of the islets known as the David Rocks, in the Noises group, is a well-established one at present. It has probably increased in numbers since the above date, and nests now extend on to the rocky slopes of the islet round the cave entrance.

A further colony can now be recorded on the Noises Islands. At least within recent years, spotted shags have also bred on cliffs on the north-eastern coast of the main island of the group, Otata Island. An attempt to breed here is believed to have been made in the 1934 season, but the birds suffered from shooting in spite of protection (pers. comm. R. A. Falla). Sibson (1948) reported nesting on 1st December, 1946, and found the colony "firmly established" on 21st December, 1948 (Sibson, 1950). According to Davenport (1951), on 2nd April, 1950, the colony consisted of approximately 40 birds, some on nests. It was occupied on 4th April, 1954, and in late August, 1954, according to notes from N. Macdonald and R. Moynihan respectively. Whether this colony has been regularly occupied since 1934 is thus uncertain, but it is of interest that none were present on 24th March, 1956, although the birds had roosted in the area fairly recently (Turbott).

Records kept by Stein since about 1919, show that Falla was incorrect in his belief that only the David Rocks colony remained at the height of persecution in 1931. Throughout the period of Stein's observations portion of the present colony situated near the eastern point of Waiheke Island was recorded. This colony has at different times consisted of three distinct groups close together on the same rocky headland, although only two of these sites are at present being used. The oldest portion occupies a cave at the northern end, and has been observed since *c.* 1919 by Stein. In a second cave to the south breeding was observed each season in the period 1924-1927, but not afterwards until 1951 and 1954, when attempts at nesting were unsuccessful. Situated roughly between these two, a third group breeds in a relatively conspicuous position on a cliff face (the "Terraces" in Stein's records). According to information from W. R. B. Oliver it was in occupation in 1916, and a photograph published by Oliver (1930a) was taken there. Stein records that in 1927, after the southern cave was abandoned, a few nests were built on the "Terraces." This group gradually increased, and has been present every year, with the exception of 1952; the greatest number recorded has been 90 birds. References to recent observations at this colony are given below in the section on breeding cycle in the Auckland area. It is located on the rocky point between Hooks Bay and Anita Bay.

Apparently the largest of the early colonies was on Shag Rock (Tarakihi Island), which lies a little over two miles to the south-east of the east point of Waiheke Island. According to Stein's observations it consisted in August, 1914, of four separate groups on the north-eastern cliffs of the island, and one additional group on the north-west corner. Stein's information continues that the birds suffered an attack in 1919, resulting in almost complete annihilation. Small numbers continued to breed until 1930, but the colony was then entirely deserted. In December, 1923, breeding was first observed some three miles to the south at the north-eastern end of Ponui Island, and it was Stein's impression that the stage of near extermination on Shag Rock was followed by a period when breeding was being attempted at both localities. The colony on Ponui Island appears to have increased gradually. Stein counted 90 in nuptial plumage on a visit in August, 1949.

On Shag Rock attempts were made at nesting in the mid-1940s*, and again at a new site in 1952, but all attempts were doubtfully successful until December, 1955, when Stein observed about 40 nests on three of the original cliff-sites. On a visit on 10th January, 1956, well-grown chicks were seen.

Observations by Cox (1946) are of interest in showing continued disturbance of the spotted shag in recent years in spite of protection since 1931. Some twenty newly constructed nests were observed on the north-east coast of Shag Rock on 11th September, 1945, but a month later the nests contained egg fragments, and no birds were seen. Buddle (1951) refers to the shooting of spotted shags at a colony in the Hauraki Gulf as recently as 1950.

A habitat group of spotted shags in the Auckland Museum was constructed by L. T. Griffin, using specimens obtained at Rakino Island

* Roberts (1943, 1944) reported breeding 1942-44, and Cox (1946) in the 1945 season, as mentioned later.

and Shag Rock in 1914: the background by the well-known landscape artist Kennett Watkins represents the early colony on Shag Rock.

On the eastern side of the Hauraki Gulf, there has apparently been a colony continuously during the above period on Motutakapu Island, one of the islands off Coromandel Peninsula to the south of Colville (Motukawao group). A. N. Breckon observed the colony on this island during the period 1920-30, and Stein has made regular observations since 1952. During recent years at least, this has been a small colony, according to Stein never containing more than 30 birds. Chicks were seen in the nests on 9th April, 1955. The colony is situated near the south-western point of the island, which is approximately 12 miles distant from the nearest colonies in the western Gulf on Shag Rock and Waiheke Island.

b. West Coast Colonies.

Three colonies are known, in an area which is somewhat different from the Hauraki Gulf ecologically, the coast being exposed, with generally a considerable swell and much heavy surf from the Tasman Sea.

The largest colony is that on Ihumoana cliff at Bethells (or Te Henga), 25 miles by road west of Auckland. The colony was first mentioned by Falla (1932), and has recently been observed regularly by Petersen as described in the present paper.

Judged by telescope and binocular views from the mainland coast, it has seemed probable that a colony existed on Oaia Island, which lies nearly a mile offshore at the south end of Muriwai Beach, and about 3½ miles north of Bethells. G. and A. T. Wightman have made landings during the past five years, and according to their observations (Wightman, 1953, and Wightman, 1956) the colony, situated low down on the north side of the island, contained nests with eggs on 11th November, 1951, and on 29th November, 1953, a nest with well-grown chicks. However, there is still some doubt as to the numbers contained in the breeding colony. The island is generally encircled by surf, often extending to the mainland, and landing earlier in the breeding season is likely to be difficult.

Spotted shags which are washed up fairly often on the west coast beaches from Muriwai to Karekare are evidently from either the Bethells or Oaia colonies (*cf.* Sibson, 1946).

The third colony on the west coast is about 50 miles to the south, and is included here as it is the only other colony on the west coast of the North Island. This is at Girdwood Point, a short distance to the south of Kaawa Creek and about nine miles south of Waikato Heads. The colony is situated both on the mainland cliff and on a tall basalt stack (Cylinder Rock) separated from the mainland by a narrow cleft. E. S. Richardson, the first to describe this colony, observed small naked chicks on 20th April, 1946 (Turbott, 1947). Sibson (1952) gave an account of a visit on 19th October, 1951, when the colony contained at least 175 pairs of breeding birds, most of which had nests with eggs.

BREEDING CYCLE AND PLUMAGE SEQUENCES.

The spotted shag has a relatively long breeding season, and most of the birds probably remain in the neighbourhood and return to the colony to roost for a great part of the year. However, it has been observed, or collected, at a considerable distance from any of the breeding stations, and movements from the breeding areas are at present mainly unknown. According to Stead (1932), parties of adults and young go on journeys up or down the coast after the breeding season, and they reach Motunau Island, some 50 miles north of the Banks Peninsula colonies.

There may also be a considerable lag in breeding at any one colony, with differences of some weeks between laying, and possibly more than one breeding peak.

The plumage sequences include the seasonal assumption of crests, decorative plumes and a distinctive head pattern. The terminology used is that adopted by Murphy (1936), whose discussion has greatly clarified the plumage changes in other southern hemisphere shags—*Phalacrocorax atriceps, Phalacrocorax albiventer, Phalacrocorax magellanicus*—in the South American region. According to Murphy, in *P. atriceps* the pre-nuptial moult occurs in the late southern summer, so that "breeding" plumage is at its height by the end of June. At this time (June-July) the gonads also begin to enlarge. With actual mating and egg-laying, a prominent feature of this plumage, the crest, is lost and the birds enter upon a distinctive stage, nuptial plumage proper. In *P. atriceps* a feature of the latter plumage is the appearance of a white alar bar. Murphy (p. 885) states that "the height of plumage should not be called a 'breeding' garb, but rather a pre-nuptial plumage, at its best during the early part of the rather lengthy courtship which precedes the nesting season," while the later stage, when the eggs are laid, is more appropriately termed nuptial plumage.

The next phase, according to Murphy, comes at the annual (or post-nuptial) moult, which results in the replacement of both the quills and body plumage, accompanied in *P. atriceps* by the appearance of a distinctive patch of white feathers on the back. This stage should be termed the post-nuptial, for as Murphy points out (p. 884) it "begins early during the nesting period as with most other cormorants": it is thus misleading to use the term "winter plumage" for this stage, which appears in the late spring and summer. The term "non-breeding plumage" must also be avoided, as the plumage is assumed while the nesting season is still in progress.

The use of the terms *pre-nuptial, nuptial* and *post-nuptial* suggested by Murphy for the seasonal plumages of the adult is most helpful, and has been adopted in the following account. Table 1 shows the phases of the breeding cycle and adult plumages, derived mainly from Petersen's notes and photographs of the spotted shag at Bethells. The information obtained by this observer is the most complete so far available, but differences in the annual cycle at other breeding stations are discussed later in this account.

Table 1. Spotted Shag: Breeding Cycle and Adult Plumage at Bethells.

Season	Decorative plumes	Crests	White head and neck line	Plumage is termed:
Pre-nuptial (begins April-May)	present	maximum	present	PRE-NUPTIAL
Egg-laying (begins August)	absent	abraded and partly moulted	present	NUPTIAL
Rearing of young (begins September)	absent	lost	obscured	POST-NUPTIAL

The above sequence is similar to that described by Murphy (p. 884) for *P. atriceps,* which is given in Table 2 for comparison (plumage terms have been added).

Table 2. *Phalacrocorax atriceps:* Breeding Cycle and Adult Plumage, according to Murphy.

Season	Crest	Alar bar	Dorsal patch	Plumage is termed:
Pre-nuptial	maximum	absent	absent	PRE-NUPTIAL
Egg-laying	abraded	present	incipient	NUPTIAL
Rearing of young	lost	maximum	maximum	POST-NUPTIAL

Note.—Of the two other South American species referred to earlier, *P. albiventer* is characterised in nuptial plumage by an alar bar, but in post-nuptial plumage this species has no white dorsal patch. In *P. magellanicus* the whole of the chin, throat and foreneck is black in pre-nuptial and nuptial plumage, but becomes white in post-nuptial. The crest is lost in both species before the post-nuptial plumage is assumed.

The following is an outline of the details of the breeding cycle, and corresponding plumages, observed at the Bethells colony by Petersen during 1952 to 1955. According to these observations, pre-nuptial plumage is assumed as early as the last week in April, and many birds have been observed in full plumage in May. There may evidently be some lag in breeding activity, as birds wearing their decorative plumes, and apparently mated, have been seen as late as 1st September. In the same part of the colony nests may contain eggs when adjacent nests have young almost ready to leave, and the last young may not be ready to fly until the end of February.*

The chief characteristics of the pre-nuptial plumage (Fig. 1) are the two fully-developed crests, the black throat and, in contrast, the wide line of white on either side of the head and neck. In addition, an often profuse decoration of narrow white plumes is scattered over the nape, back, rump and flanks.

In July, nest-building generally begins in earnest: the birds are seen carrying long sections of seaweed, or green cliff herbage, and the colony generally contains well-built but empty nests.† Until this time they sit about the colony with a certain amount of courtship.

* The seaward (western) portion of the colony is the earliest to start, according to Petersen's records, and is from three weeks to a month more advanced than the more inland (eastern) portions, occupying the inner cliffs.

† Carrying of nest material was observed in the first week in June at Bethells (Turbott, 1946).

The transition from pre-nuptial into nuptial plumage is characterised by the loss of the decorative plumes and the reduction of the crests by wear and moult. The period during which the plumes is retained is very variable, according to Petersen's observations, and apparently they are not developed at all in some birds. In many birds they are lost after only a few weeks, but they may remain for much longer and even persist very exceptionally until the eggs have been laid. The crests generally become much reduced before egg-laying, and disappear soon afterwards. There is thus a period of perhaps two months (June-July) when most birds have lost the decorative plumes, but are characterised by the black throat, white stripe on head and neck, and distinct but diminishing crests (Figs. 2-4) : the nuptial plumage.

The earliest eggs observed were found in the second week in August, but laying may evidently begin even earlier, as a chick was found just hatched on 1st September. Incubation takes over four, and less than five, weeks, according to Petersen's observations. Both parents incubate, and the change over was observed on several occasions.

With the laying of their eggs the birds enter upon the post-nuptial moult, according to Petersen's observations. By the time of hatching both parents have changed into post-nuptial plumage. As mentioned above, the crests are soon lost, and brown or greyish-brown flecks appear on the white line as early as egg-laying, gradually increasing until hatching. The black throat becomes mottled with grey and white, or may even become a featureless pale grey or almost white (see below under "adult plumages"). The dark line down the mid-line of crown and hind-neck also becomes greyish brown. The effect of these changes is to reduce the tone of the striking head and neck colouration by replacing it with more or less mottled grey and white, but the rate of change varies greatly, and the degree of pattern on the head and neck varies in post-nuptial plumage (Figs. 6-10).

The fledging of several chicks took about nine weeks, at which stage the young were observed to fly. The earliest record for a newly-hatched chick was 1st September, and the latest was the third week in December. On the more open slopes, the fledglings tend to clamber about away from the nests when only six to seven weeks old, but on narrow ledges cut off from the rest of the colony the entire fledging period of individual chicks could be observed. At this stage the most notable feature of the colony is the resemblance superficially between the young in their juvenal plumage and the post-nuptial adults, especially those in the "greyer" type of plumage. The juvenals can be distinguished by the brownish lower back and flanks, white under tail-coverts and, at close range, by the pinkish facial skin. The spots on the back are much less pronounced than in the adult.

The following are notes on material in the Auckland Museum, chiefly from the Hauraki Gulf, where collections were made some years ago, and from west coast beaches, where more recently a series of storm-killed birds has been obtained. In addition to the record of plumage sequences by Petersen, information is included from my own field notes.

Juvenile Plumages: Nestling

The naked chick has a dark lead grey skin; in a chick examined at the David Rocks, Hauraki Gulf, on 11th May, 1935, the first down was just appearing as a sparse coat, dark above and whitish below (Turbott).

The first nestling down, which is described by Oliver (1955) as "dark brown above, whitish below," is shown in Petersen's photographs of the younger chicks (Fig. 9). There are several specimens, all apparently of about the same age, in the Auckland Museum collection (Nos. AV. 96.6, included in exhibition group; 96.106 and 96.107). A noteworthy feature is the brownish face and under-parts. However, in AV. 96.107 the face is white, and the head pattern in this down may well prove to vary considerably. It seems probable that the under surface gradually becomes whiter as the second down is acquired.

The second down is shown by a fledgling in the collection, AV. 96.101, found on Bethells Beach, 8th December, 1951. In this there is a very distinct demarcation between the ashy-brown of crown, hind-neck and dorsal surface, and the under surface, which is white including the face to the level of the eye and the fore-neck. Only a trace of brown appears on the breast and abdomen. The quills and scapulars are well grown. Small filoplumes are scattered through the down on the hind-neck. The bare facial skin and gular pouch, which are pinkish in life in both fledglings and juvenals (Turbott), were a faint greenish-blue in the fresh specimen. The feet appear flesh-coloured in life, but in the fresh specimen had faded to a dull yellowish grey; the tarsus, outer toe and webs with brown shading. Fig. 10 shows nestlings at this stage.

Juvenal

As already mentioned, this can be recognised fairly readily by several characters in the field, the most satisfactory being the whitish under tail-coverts only faintly shaded with brown. The under tail-coverts and lower half of the abdomen in later plumages are dark grey to deep greenish black.

A juvenal, AV. 96.102 (Bethells Beach, 8th December, 1951) has the upper parts and thighs grey brown, faintly glossed with green on the lower back, upper tail-coverts and thighs; and the wing and tail quills dark brown. The chin is white, merging with the pale brown of the sides of the head, fore-neck and upper breast. The abdomen and under tail-coverts are white lightly shaded with brown. The feathers of the mantle, scapulars and wing-coverts have greenish-brown tips, the spots so formed being relatively faint. Filoplumes are present on the hind-neck and thighs. In this specimen the coloration of the facial skin and feet was similar to the fledgling described above (AV. 96.101), but there was more brown shading on the feet. Petersen's photographs also show this plumage (Fig. 11).

Oliver (1955) gives a detailed description of the juvenal plumage under the heading "immature," but states that there is a "stripe on side of neck mottled ashy brown and white," a characteristic of sub-adult or adult post-nuptial plumage.

Sub-adult

Information at present remains inconclusive on the later immature plumages and little can be added without larger collections, or further field work based upon ringing. It is doubtful whether classification as immature on labels, based on the condition of the gonads, is reliable. The labels have thus not been followed except when confirmed by plumage characters in the following material.

According to Stead (1932) the spotted shag breeds at the end of its first year, a conclusion based on the presence of a group of birds in the colony moulting into "mating plumage" some two months later than the main colony. These birds, which occupied an area near the colony, were considered by Stead to be the young of last year's breeding season. Some individuals were still in full juvenal plumage, and according to Stead were no doubt "late-hatched ones of the previous year."

The presence of a similar group of presumably sub-adult birds towards the outskirts of the colony, moulting into pre-nuptial plumage at a late stage in the nesting season, was noted by Petersen at Bethells.

Falla (1932) stated that the juvenal plumage is followed at the next moult by a stage which, according to his description, corresponds in most characters to the adult post-nuptial plumage. The description includes the statement: "The stripe down the side of the neck remains mottled ashy brown and white until the assumption of the nuptial ornaments consisting of frontal and occipital crests, and extensive series of elongated white feathers of fine texture." However, the two specimens (AV. 96.3 and 96.72) upon which the description is based are both of the type with a fairly definite pattern on the head and throat, and show no characters to distinguish them from the strongly-patterned type of adult in post-nuptial plumage. Falla also examined two specimens moulting out of juvenal plumage (AV. 96.5, 96.71).

The series in moult described below shows that the post-juvenal moult, when the birds probably pass into a "post-juvenal" plumage, occurs not long after the breeding season. The most advanced of the specimens (AV. 96.84, 96.90, 96.108) have almost completely changed into a plumage which is indistinguishable from the "greyer" type of post-nuptial adult. However, the material is insufficient to indicate whether this coloration is constant at the post-juvenal stage, so that at present no distinction can be drawn between this stage and the corresponding adult plumage (adult post-nuptial). Stead's observations suggest that this is followed by a "first pre-nuptial plumage" which is apparently indistinguishable from adult pre-nuptial plumage.

Specimens in the Auckland Museum collection at some stage of moult out of juvenal plumage are as follows:

No. AV. 96.5 *Bay of Islands; 1896.* Throat and fore-neck lightly shaded with grey. New spotted plumage on mantle and scapulars, mixed with some faded brown feathers. Black upper tail-coverts appearing at base of tail. Flanks brown. Under tail-coverts still whitish, but a group of dark grey feathers at the vent.

AV. 96.71. *Female; Thames; 29th June, 1882.* New spotted plumage on mantle and scapulars, with some faded brown feathers. Black over base of tail, but otherwise in juvenal plumage.

AV. 96.84. *"Juv. male"; Muriwai Beach; 12th May, 1933.* Faint grey shading on throat and fore-neck. Mantle and scapulars almost completely replaced; greenish-black feathers scattered over hind-neck, lower back and rump, above base of tail, and a few on the flanks. Under tail-coverts white, with scattered dark grey feathers. Two new black middle tail quills; remaining quills much faded.

AV. 96.90. *Immature female; Muriwai Beach; 27th August, 1935.* As adult post-nuptial plumage, except for the much-faded wing-coverts where replacement is beginning, some remaining brown feathers on the flanks, and two faded tail quills. The throat and fore-neck are lightly shaded with grey, as in AV. 96.84. The lower abdomen and under tail-coverts are dark grey, darkest on the under tail-coverts. The whole remaining under-parts are suffused with pale ashy grey. It will be noted that, but for juvenal characters recorded above, this specimen might be regarded as a post-nuptial adult of the palest type quite frequently observed amongst breeding birds.

Av. 96.103. *Female; Muriwai Beach; 18th May, 1951.* Much like AV. 96.5 and 96.84, but fewer feathers replaced on the mantle and scapulars; less advanced than AV. 96.84 on lower back and flanks.

AV. 96.108. *Muriwai Beach; 21st May, 1934.* Like AV. 96.84, but all the upper-parts replaced except the faded wing-coverts (replacement beginning). A good deal of brown remaining on the flanks. Lower abdomen and under tail-coverts almost replaced by dark grey, but scattered white feathers remaining in front. In addition to the two middle tail quills, two side quills are being replaced. The under-parts suffused with pale ashy grey as in AV. 96.90.

AV. 96.110. *Piha Beach (West Coast); 12th February, 1956.* This specimen was decomposed and only a wing was kept. It was at an early stage of the post-juvenal moult, having new black-tipped feathers under the juvenal feathers on the mantle and scapulars. Wing coverts and scapulars faded to pale greyish brown.

All the above specimens show, in addition to the characters described, a faded region on the wing coverts, and, in the less advanced specimens, on the scapulars. This marking is prominent in the field and is referred to by Stead (1932) as "pale sandy yellow." When the juvenal plumage is first acquired the wing coverts have dark-brown spotted tips as noted above, but the soft feathers of this plumage tend to wear rapidly at the tips. This is accompanied by fading, especially on the scapulars and wing coverts.

In two of the above specimens (AV. 96.90 and 96.108) the lower abdomen and under tail-coverts have changed to dark grey. This coloration may be an immature character, but it should be noted that a breeding bird photographed by Petersen (Fig. 3) shows dark grey between the thighs. There is also a variable amount of dark grey, often mottled with black, on the anterior portion of this region in specimens which are otherwise in adult plumage, and in some as little as a trace of dark grey on the black. The latter include both sexes in nuptial and post-nuptial plumage.

The following specimen (the only one in the collection from this locality) is included tentatively under this heading:

AV. 96.78. *Immature; Queen Charlotte Sound; 26th August.* Plumage like the adult post-nuptial, having a white stripe on head and neck, flecked with brown; throat dark grey faintly mottled

with pale grey and white; greenish-black feathers appearing on the crown and hind-neck, and well developed on the anterior mantle. Crests sprouting beneath the feathers. Filoplumes present on hind-neck and back, and abundantly on the flanks.

This is possibly a sub-adult, as the greater wing-coverts are faded, although the remaining wing-coverts and scapulars have all been replaced. In addition, it is evidently in the process of changing into pre-nuptial plumage. By this season (26th August) at Bethells, only young of the previous year would be at this stage; and at the Noises Islands, Hauraki Gulf, the pre-nuptial moult would be mainly earlier in the year. It might, however, be a post-nuptial adult from a later breeding colony (such as that on eastern Waiheke Island). Perhaps some fading occurs during the later stages of the adult post-nuptial moult.

Observations were also made on a visit to the David Rocks (Noises Islands) colony on 3th March, 1956. A bird changing out of juvenal plumage observed closely showed the much abraded juvenal feathers on the mantle and scapulars, amongst which a dozen fresh grey feathers with black tips were conspicuous. There were fresh dark feathers above the base of the tail, but otherwise the back and flanks were apparently still brown; the tail quills were partly replaced. The under tail-coverts were whitish, and the head and neck coloration like the juvenal. The bare facial skin in this sub-adult bird was chrome yellow, whereas in post-nuptial individuals observed at the same time, and presumed to be adults, the skin was yellow distinctly tinged with olive-green. The feet were mainly dark brown, slightly pinkish. (Turbott.)

Adult Plumages: Pre-nuptial and Nuptial

There is a series in various stages of pre-nuptial and nuptial plumage in the collection. The following is a brief description of the plumage at these two stages: The side of the head, throat and fore-neck are dull black, with a faint green gloss; above this a line of pure white extends down the side of the head and neck, and continues but becomes narrower between the mantle and fore-neck, until it reaches the wing. The crests, crown and a narrow line on the hind-neck are black, with a brilliant green gloss; glossy greenish black extends on to a wider zone on the anterior portion of the mantle, and there merges with the spotted dorsal plumage. The posterior mantle, scapulars and wing-coverts are ashy brown, each feather bearing a greenish black terminal spot; the wing quills are brown with a grey bloom. The lower back, rump and upper tail-coverts, continuing below to the flanks, under tail-coverts and lower abdomen, are glossy greenish black. This meets the abdomen at a distinct line across the body, linking the thighs*. The breast and upper abdomen are pale silver-grey. In pre-nuptial plumage, white decorative plumes may almost completely hide the dark mid-line of the neck, and sometimes occur on the mantle, back and rump, and on the thighs.

Notes on a specimen in nuptial plumage (AV. 96.105) state: "feet yellow, soles (under toes) dark brown; bill horn colour, brown on top of culmen" (Turbott).

* Variations in the coloration of this region are mentioned under "sub-adult."

The bare facial skin and gular pouch in pre-nuptial plumage are generally described as dark blue ("rich royal blue," according to Stead) and the ring of beads round the eye greenish blue (for the general appearance of the facial characters see Fig. 1). As already mentioned, birds in post-nuptial plumage, probably adults, observed on the David Rocks on 3rd March, 1956, had olive-green to yellow skin on the face (Turbott). Field notes are recorded by Falla (1932) for a post-nuptial in which the skin in this region was "viridine green." It thus seems probable that the bare skin changes to bluish green, and finally to greenish yellow during the transition into post-nuptial plumage, but confirmation could be obtained by field observation in the breeding season.

The following specimens in pre-nuptial and nuptial plumages are included in the series in the Auckland Museum:

No. AV. 96.1. *Male; Rakino Island; 1886.* Nuptial.

AV. 96.4. *Rakino Island, 1887.* Pre-nuptial.

AV. 96.83. *Female; Muriwai Beach, 12th June, 1933.* Moult is still in progress on the head and mantle, but this specimen is almost in full pre-nuptial plumage.

AV. 96.105. *Female; Muriwai Beach; 15th July, 1951.* Apparently in full pre-nuptial, although there are only a few scattered white plumes on hind-neck and thighs. Two side quills sprouting in the tail (*cf.* Murphy, *ibid.*, with regard to the protracted period required for the replacement of the quills in *P. atriceps*, moult still showing in some specimens as late as April).

The observations made at Bethells by Petersen show evidence of the change out of nuptial plumage soon after egg-laying. The crests have been lost and the white lateral line obscured by the time the eggs hatch. However, Petersen's photographs taken at a considerably later stage, some two months after laying, provide some evidence that the period taken to moult the black throat may be variable. By this time, the moult of these black feathers is complete, or almost complete, in some individuals (Figs. 7 and 9). However, in a number apparently mainly with the more pronounced type of head pattern (Figs. 6 and 8), there are still plentiful scattered black feathers on the throat. These appear to be wholly lost before the next pre-nuptial moult, as specimens of this strongly-patterned type changing again into pre-nuptial plumage are included in the collection, and show fresh black feathers on the throat, which is otherwise mottled dark grey and white.

It is not possible at present to distinguish between the sexes in the field. Petersen found that, of the three pairs which he photographed, one bird appeared to be smaller and was more confident at the nest. In each pair, the smaller was the duller in nuptial, and of the "greyer" type in post-nuptial, and was considered to be the female. However, the specimens in post-nuptial plumage mentioned below include both males and females with both types of pattern.

The principal changes marking the transition to post-nuptial plumage are: (a) *The appearance of brown or greyish brown feathers as flecks in the white line.* These occur along the whole length of the white line, and may even be so numerous that the line is practically obscured (Figs. 6 and 8). They are present in both sexes in the collection, and persist in specimens which are moulting again into pre-nuptial

plumage. In the "greyer" type of post-nuptial individual the line is indistinct, as the greyish brown on crown and hind-neck becomes merged into almost the same shade on the side of the head and neck (Figs. 7 and 9). (b) *Mottling of the throat region,* again with considerable variation ranging from individuals with pronounced mottling to those showing the extreme "greyer" coloration. In the former, the throat is uniform dark grey, or mottled dark grey and white, in the post-nuptial plumage; black feathers may be present, but, as mentioned above, it is uncertain how long these are retained. The "greyer" type is a featureless pale grey with a white chin in extreme cases, but the chin and throat are quite commonly a darker shade of grey, mottled more or less with white. As shown by a specimen (AV. 96.89) included below, replacement of the black throat starts on the chin round the base of the bill, and Oliver (1955) has a photograph (p. 231) of a bird, wrongly stated to be "immature," which is evidently at about this stage.

The following specimens illustrate several stages of transition to post-nuptial plumage:

AV. 96.89. *Female, Muriwai Beach; 7th September, 1936.* In nuptial plumage, but with a few scattered brown flecks on the dorsal half of the white line, and dark grey feathers appearing on the black chin at the base of the bill.

AV. 96.3. *Female; Whangaparaoa; 5th September, 1896.* Brown flecks present on the white line. Grey, white and black feathers on the throat. On the crown, hind-neck and mantle there are still greenish black feathers in the new grey-brown plumage.

AV. 96.72. *Waiheke Island.* Throat dark grey, mottled with white. Crown and hind-neck greyish brown, white line indistinct and narrow. Some dark greenish black feathers on the lower hind-neck and mantle.

AV. 96.77. *Male; Noises Islands; 30th May, 1932.* Similar to AV. 96.72, but the throat is dark grey only faintly mottled with pale grey and white. Filoplumes are numerous on the head, and there are a few short decorative plumes on the hind-neck. Although collected at such an early date, this bird appears to have performed the post-nuptial moult, but breeding begins considerably earlier at the Noises Islands (David Rocks) than at Bethells (see below). It may be coming into pre-nuptial moult, although apart from the dark feathers on the hind-neck and mantle no signs of this are yet present.

Through the courtesy of Dr. R. A. Falla and Mr. C. McCann a further specimen has been received on loan from the Dominion Museum, Wellington (DM. 1837). It is a female collected off Lyttelton, 28th January, 1926, by R. H. Beck, and is of special interest as it is in the palest "greyer" type of post-nuptial plumage, and shows a sprinkling of black feathers in the grey plumage on either side of head and fore-neck. There is no evidence of moult, and, as suggested above, these black feathers have apparently persisted until a late stage, but would probably be lost before the next pre-nuptial moult.

Post-nuptial

The collection includes two specimens in the "greyer" type of post-nuptial plumage. The throat in both specimens is mottled with dark grey

and white, forming an indistinct grey shadow. The crown and hind-neck are greyish brown, with a faint green gloss, darkening only slightly on the mantle. These specimens are:

AV. 96.79. *"Immature" male; Karekare Beach (West Coast); 26th February, 1933.* (Labelled "immature" but there is no basis for this on plumage characters.)

AV. 96.82. *Female; Karekare Beach; 4th April, 1933.*

In addition, the following specimens are evidently in the process of changing into pre-nuptial plumage:

AV. 96.80. *Female; Noises Islands; 28th March, 1933.* Crests well-developed, and perhaps still growing. New dark feathers growing and already abundant on crown, hind-neck and mantle. Brown feathers still sprinkled in the already distinct white line. Filoplumes on head and neck, including throat; some sho t decorative white plumes on the hind-neck and flanks. The chin and throat still show some grey and white feathers, but many new black feathers have appeared, giving a dark grey effect generally. A side tail quill sprouting and the two central quills only half grown.

AV. 96.87. *Female; Hauraki Gulf; 30th April, 1935.* Like 96.80, but more black feathers have appeared on the chin and throat, which has a generally darker appearance. The crests are not so strongly developed.

AV. 96.93. *"Immature"; Muriwai Beach; 12th April, 1942.* The white line is much less evident than in the two specimens above, being still almost obscured by brown feathers; new dark feathers are less abundant on the crown, hind-neck and upper mantle. The crests are short, but sprouting. There is only a sprinkling of black feathers on the chin and throat mixed with the grey and white. A few filoplumes on the crown and hind-neck, and scattered short white decorative plumes on the lower back and flanks. Some faded brown quills in the tail, but mainly replaced. (Labelled "immature" but see AV. 96.79.)

AV. 96.94. *Female; Muriwai Beach; 12th April, 1942.* Resembles AV. 96.93 closely, but decorative plumes almost absent on the lower back; the white line is less heavily flecked with brown.

BREEDING CYCLE IN THE AUCKLAND AREA

As Petersen's observations at Bethells show that the colony there follows a fairly regular annual cycle, in the present section this cycle is compared with the information available from other colonies in the Auckland area.

Unfortunately, there are only somewhat scattered observations on colonies at the Noises Islands, and the large amount of field work by Stein refers mainly to the eastern Waiheke Island colony, where breeding is evidently exceptionally irregular. The opportunity is taken to include in this section some additional notes on the Bethells colony.

At the Noises Islands, the colony situated for so long in and outside the entrance to a cave at the David Rocks seems to have a generally

earlier breeding season than the one at Bethells. Falla (1932) found that "the cavern-dwelling colony that alone now represents the species on the western side of the Hauraki Gulf has for some years past been breeding in mid-winter." He says: "Full nuptial plumage is present in most of the birds in May, by the end of which month in 1932, about twenty new nests of green *Mesembryanthemum australe* had been built up, but no eggs laid." However, the season may be prolonged until October, eggs having been observed in this month, and the season thus extends almost as late as the Bethells colony.

Some 200 birds were counted when the colony was visited on 3rd March, 1956, but examination of the cave showed that nesting had not yet started. In addition to the juvenals mentioned earlier, several adults were seen with the white stripe already distinct on head and neck, and the position of incipient crests could be seen in one bird observed at close quarters (Turbott). It is worth noting that this is approximately one month before the first birds assume pre-nuptial plumage at Bethells according to Petersen's observations. On a visit to the latter colony only six days earlier, on 27th February, none had been seen changing plumage (Turbott).

The earliest breeding record at the David Rocks was made on 11th May, 1935, nearly three years after the account by Falla (1932). The colony was then low in numbers, only about 54 birds being present. Of these, a number were in pre-nuptial or nuptial plumage and one nest contained three young chicks in sparse down. There were also a number of empty but completed nests, substantially built of seaweed and ice-plant, *Mesembryanthemum australe* (now *Disphyma australe*). Some birds were in non-breeding plumage, and were apparently either the earliest adults in post-nuptial, or those not yet changed into pre-nuptial plumage. Further, the colonies at this season also contain sub-adults, still at the post-juvenal stage, which, as mentioned above, it is not yet possible to distinguish from the adults. (Turbott.)

The colony was examined by Stein on 31st March, 1956, but only one bird showed signs of pre-nuptial plumage: the throat was almost black and dark feathers were present on the crown. There were also incipient crests, still almost hidden.

From these observations, it is evident that the onset of breeding is irregular in this colony, or has changed since the period of Falla's observations. Further, the period between the pre-nuptial moult and egg-laying—a full three months at Bethells—may prove to be comparatively short at the David Rocks, as the earliest hatching recorded is in early May (laying approximately a month earlier), but the pre-nuptial moult was evidently just beginning on visits on 3rd and 31st March. A connected series of several years' observations are now needed on the breeding cycle in this colony.

Evidence is also given by Cox (1946) of much later breeding at this colony, as nests were being reconditioned and built on a visit on 31st July, 1946. One nest contained two eggs, apparently well incubated. Fleming (1940) visited the colony on 6th August, 1938, and found "nest building in progress, four well-grown young and three clutches of fresh-looking eggs." Fleming also reports that in October, 1939, there were "all stages of young and eggs."

Two specimens, included in the section above, may be mentioned, as they give additional information in relation to the David Rocks colony. In AV. 96.77, as already mentioned, it is likely that the post-nuptial moult is almost complete, although alternatively the specimen may be just entering into the pre-nuptial moult. In the former case, the date of collecting (30th May) would correspond to the earliest hatching at the colony. In AV. 96.80 pre-nuptial plumage is being assumed on 28th March, and laying and hatching would probably in this case be considerably later. Unfortunately, full data are not given with several earlier specimens from the Hauraki Gulf.

On Otata Island, the largest island of the Noises group, the colony may not be regularly occupied, as mentioned earlier. The few observations available on this colony are of considerable interest, as the commencement of breeding apparently corresponds to the earliest dates for the David Rocks colony. On 2nd April, 1950, Davenport (1951) found that there were some birds on nests; and on this visit (pers. comm.) saw two nests each containing a clean egg, which had apparently only recently been laid. Sibson (1948) reported approximately 10 nests in this colony, but only four birds were seen during his visit on 1st December, 1946. By this date, the breeding season was probably nearly over.

The colony on eastern Waiheke Island, near Anita Bay, has been observed more systematically by Stein. Two groups included in this colony are relatively inaccessible, as they are cave-dwelling, and Stein's detailed observations on breeding have been made mainly on the cliff nesting portion of the colony (the "Terraces"). In addition to regular visits by Stein, the following are notes on the colony made by other observers: (a) According to Oliver (1930a), eggs were found in January, and a photograph is shown (taken on 1st January, 1916, pers. comm., W. R. B. Oliver). (b) Cox (1946) examined the colony which was "nesting in a small cave, some ten or twelve nests being located on ledges within two or three feet of the cave roof." This visit was on 23rd October, 1945, and the nests that could be examined contained eggs. (c) On 29th September, 1946, according to Buddle, Sibson and Fleming (1947), there were "about 40 birds and 17-20 nests; few adults still crested; of 11 nests, three new and empty, one with three eggs, rest with young up to nine inches high." (d) McKenzie (1948) states that the colony consisted of 55 occupied nests containing eggs or young, when visited by T. M. Roberts on 28th December, 1946. About 55 young, some newly-hatched, were counted on a later visit by McKenzie on 25th January, 1947; and the nests were empty on 23rd February, 1947, although there were still many young in the colony. Finally (e) photographs taken by G. A. Buddle in 1946 of the "Terraces" portion of the colony are shown by Buddle (1951) and Oliver (1955).

A brief summary of Stein's observations gives the following information on the breeding cycle on the "Terraces." A large proportion are in *nuptial plumage* in August. In addition, beginning in 1949, it has been found that a number assume nuptial plumage by the second and third weeks of February. At three separate periods *eggs* are observed: in late August, in December and (observed from 1950) in March. The young chicks are present in early October, January and April. As shown by Stein's observations, these dates represent separate breeding

peaks and were not due to disturbance followed by attempts at re-nesting. The peaks have been observed during successive years. It would be of special interest to follow up the breeding cycle in this colony by colour ringing. Although the August and March laying periods evidently correspond to the peaks of nuptial plumage in August and February respectively, there were no observations of nuptial plumage preceding the egg-laying period in December. It will be noticed further that the pre-nuptial stage is not included in the observations, but this would occur, at least before the first peak of breeding, while no visits were being made in mid-winter. Birds in pre-nuptial plumage were not observed before the later breeding peaks.

A few additional notes may be given on the Bethells colony, as these suggest some modification of the annual cycle based on Petersen's records. Fleming (1940) on 11th June, 1939, recorded "incubating, nest material carried," but his field notes (pers. comm.) show that the use of the term "incubating" was not justified as no eggs were seen. Birds sitting on well built or partly-finished nests would suggest that breeding had started some weeks earlier than found by Petersen. Macdonald (1951) notes that there were no young to be seen on 23rd September, 1950, when the landward portion of the colony was examined: it would appear from Petersen's record that young are generally present by this date. Observations on visits on 24th November and 8th December, 1951, conformed fairly closely to Petersen's: fledglings were seen in the nests on 24th November and a number were in juvenal plumage on 8th December, although on this date the least advanced were still downy chicks in the nest (Turbott)*.

On 31st March, 1956, 10 birds were observed fairly closely on the landward portion of the colony, eight clearly showing newly sprouting crests and greyish-black or black throats, as would be expected according to the cycle observed by Petersen. There were several with an almost pure white line on head and neck, but in others numerous brown flecks still present on the line were visible. Two appeared to be in post-nuptial plumage with no signs of moult. (Turbott.)

The only observations from other west coast colonies suggest that the breeding cycle is approximately the same as at the Bethells colony: well-grown chicks in late November at Oaia Island and eggs in mid-October at Girdwood Point. However, it is significant that small naked chicks were observed at Girdwood Point on 20th April, 1946, by E. S. Richardson, and there may be a particularly extended season at this colony, or there may be more than one breeding peak. In addition, there is some doubt regarding the breeding season at Oaia Island, as Fleming (1940) reports finding a "downy chick," probably from this island, washed up on Muriwai Beach on 17th June, 1939. This record suggests that breeding may also be extended here, with the beginning of egg-laying early in the year.

In Table 3 the information available on the David Rocks and eastern Waiheke Island colonies is summarised and compared with the breeding cycle at Bethells.

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* Two specimens, a fledgling (AV. 96.101) and a juvenal (AV. 96.102) found on the beach at Bethells on this date are included in the material described earlier.

Table 3. Breeding Cycle of the Spotted Shag at Bethells and in the Hauraki Gulf.

	Roosting on site of colony. (Post-nuptial plumage)	Courtship, nest-building. (Pre-nuptial and nuptial plumage)	Eggs laid. (Nuptial plumage)	Young hatch. (Post-nuptial plumage)	Young leave the nest. (Post-nuptial plumage)
Bethells	Feb.-April	begins April-May	begins August	begins September	begins November
Eastern Waiheke I.	?	Nuptial plumage Aug. (pre-nuptial and nuptial suppressed?) Nuptial plumage Feb. (pre-nuptial suppressed?)	late Aug. December March	early Oct. January April	no records
David Rocks (Noises Is.)	?	April —?	April, July, Aug., Oct. (scattered records only)	May, Aug., October (scattered records only)	no records

A major factor, which may have affected breeding times and resulted in the differences in breeding season between the Hauraki Gulf and the west coast, was the early uncontrolled destruction of the colonies in the Hauraki Gulf. However, as noted above, there is some evidence that Bethells differs from the other west coast colonies (Oaia Island and Girdwood Point), and it is not known whether there was disturbance of any of the west coast colonies. When fuller information has been obtained, a comparison of the breeding cycle at the colonies in the Auckland area may suggest other factors resulting in differences in breeding season from colony to colony.

SUMMARY

1. The past and present distribution of the spotted shag in the Auckland area is outlined. In addition to a colony previously recorded, another colony is known to have survived in the eastern Hauraki Gulf during the period of greatest destruction, 1910-1931.

2. Terminology for stages of plumage as suggested by Murphy for certain South American shags is adopted, as it conforms to data on the colony at Bethells. Field notes on the breeding cycle and corresponding plumage changes at Bethells are given, and material in the Auckland Museum discussed with reference to the field observations.

3. It was not possible to find a satisfactory means of distinguishing between the post-juvenal stage (i.e., the first plumage following the juvenal) and the corresponding adult plumage (adult post-nuptial). An investigation based on ringing would indicate whether this plumage differs from the adult. The first pre-nuptial plumage apparently does not differ from the adult pre-nuptial.

4. The observations on breeding cycle at Bethells are compared with the records available from colonies on the David Rocks and eastern Waiheke Island (Hauraki Gulf), and differences in breeding seasons are briefly discussed.

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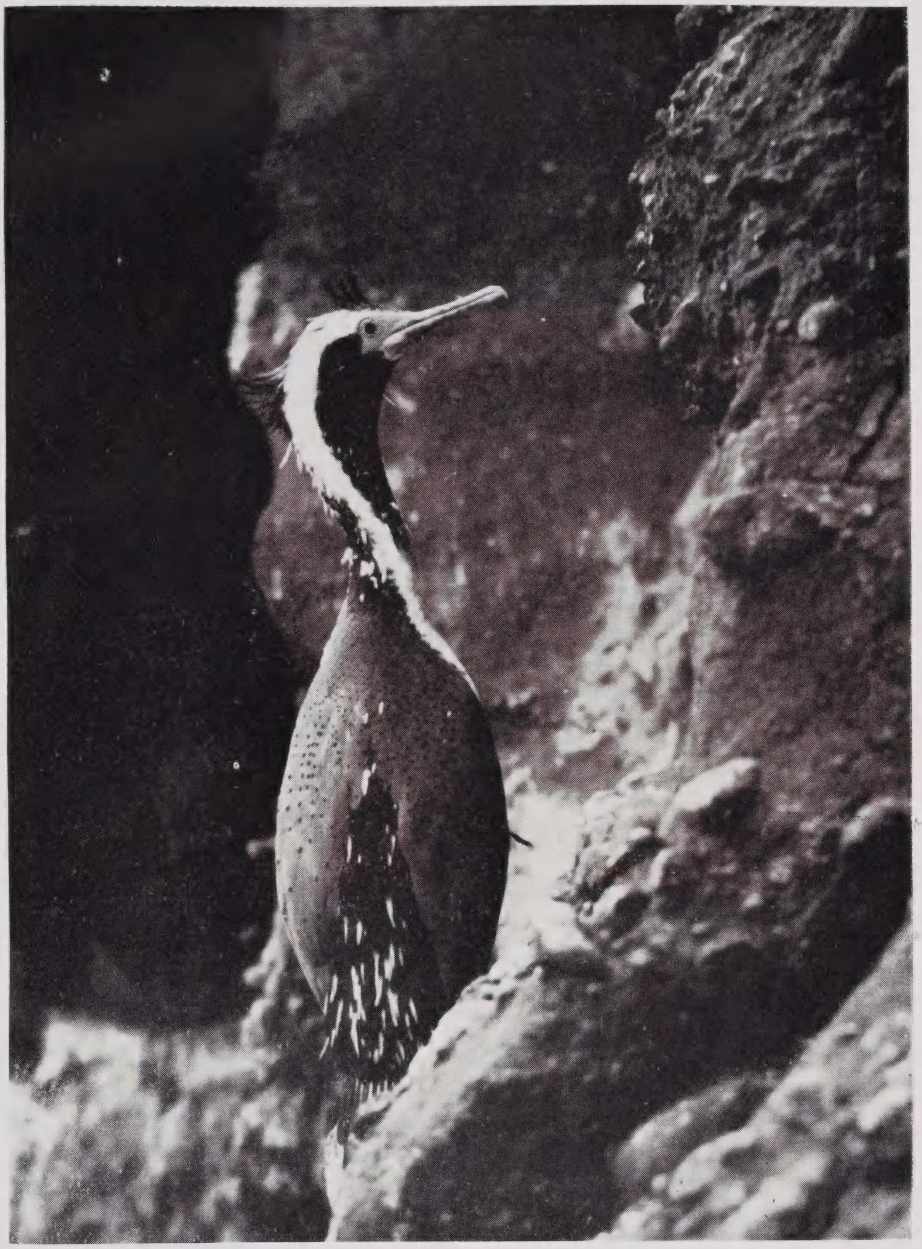

Fig. 1. Spotted shag in *pre-nuptial plumage* showing the characteristic decorative plumes on the nape, back and rump. The transition to nuptial plumage is marked by the loss of the decorative plumes and reduction of the crests by wear and moult. Bethells colony.

Photo: O. Petersen.

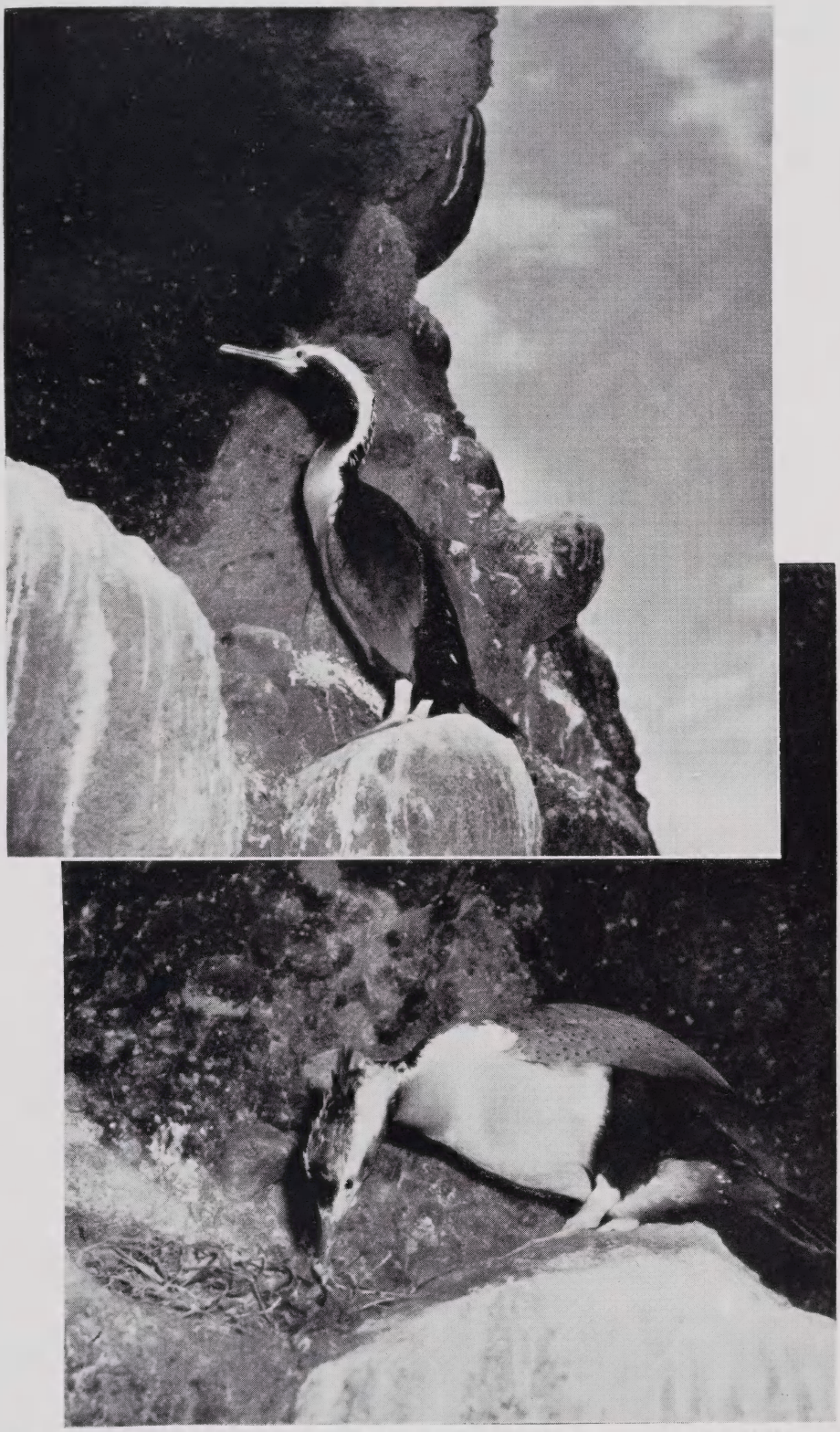

Fig. 2. *Nuptial plumage*, characterised by the black throat, white lateral line on head and neck, and distinct but diminishing crests. Adult close to nest, nest B, early August, 1953. Bethells. This bird is shown in post-nuptial plumage in Fig. 6.

Fig. 3. *Nuptial plumage:* mate of the above nest-building, nest B, early August, 1953: shown in post-nuptial plumage in Fig. 7. In this and the bird above a few decorative plumes have not yet been shed.

Photos: O. Petersen.

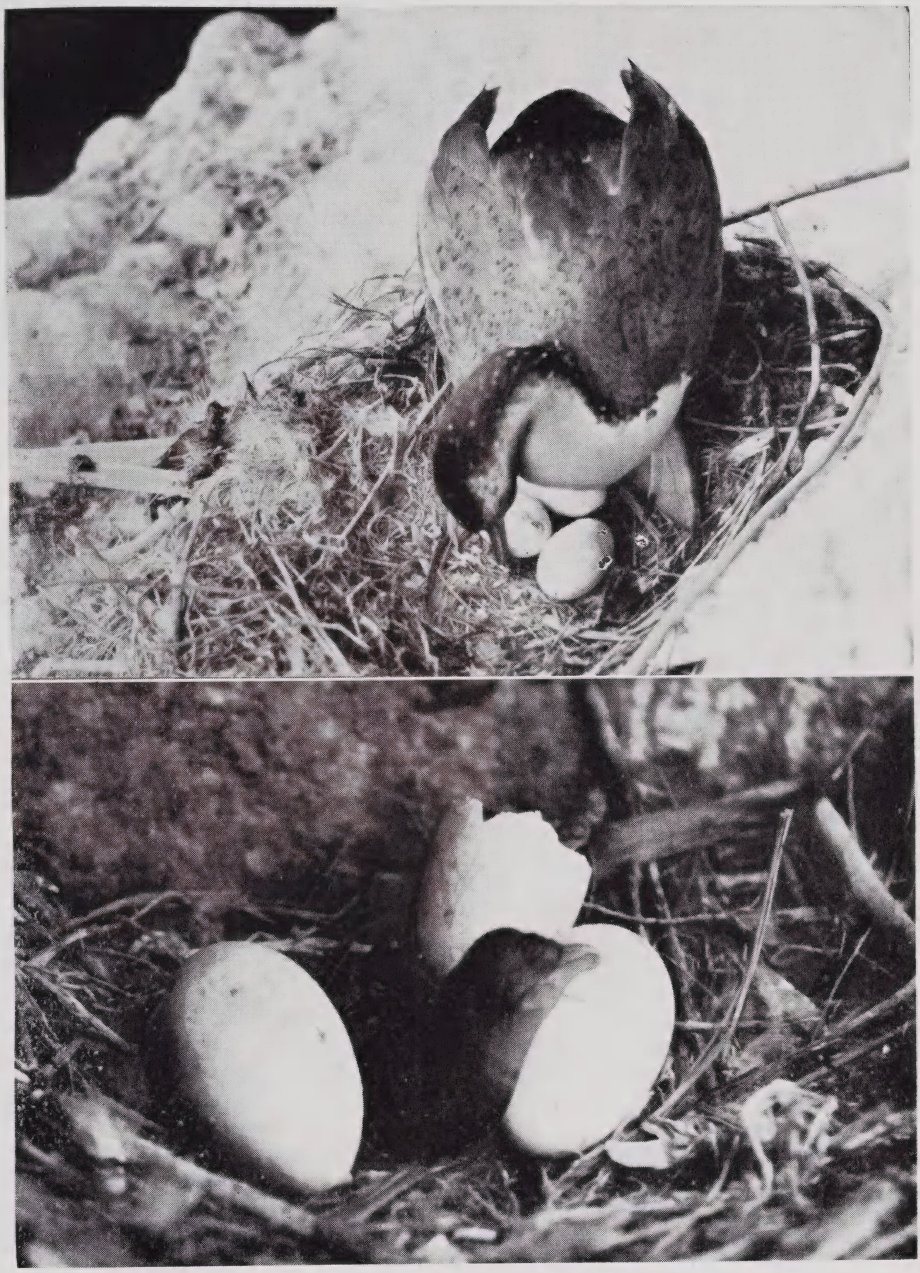

Fig. 4. *Nuptial plumage,* showing transition to post-nuptial during incubation. The crests have been lost and brown flecks are appearing in the white line on head and neck. Nest C, September, 1954, Bethells.

Fig. 5. Newly hatched chick, nest A, October, 1952, Bethells.

Photos: O. Petersen.

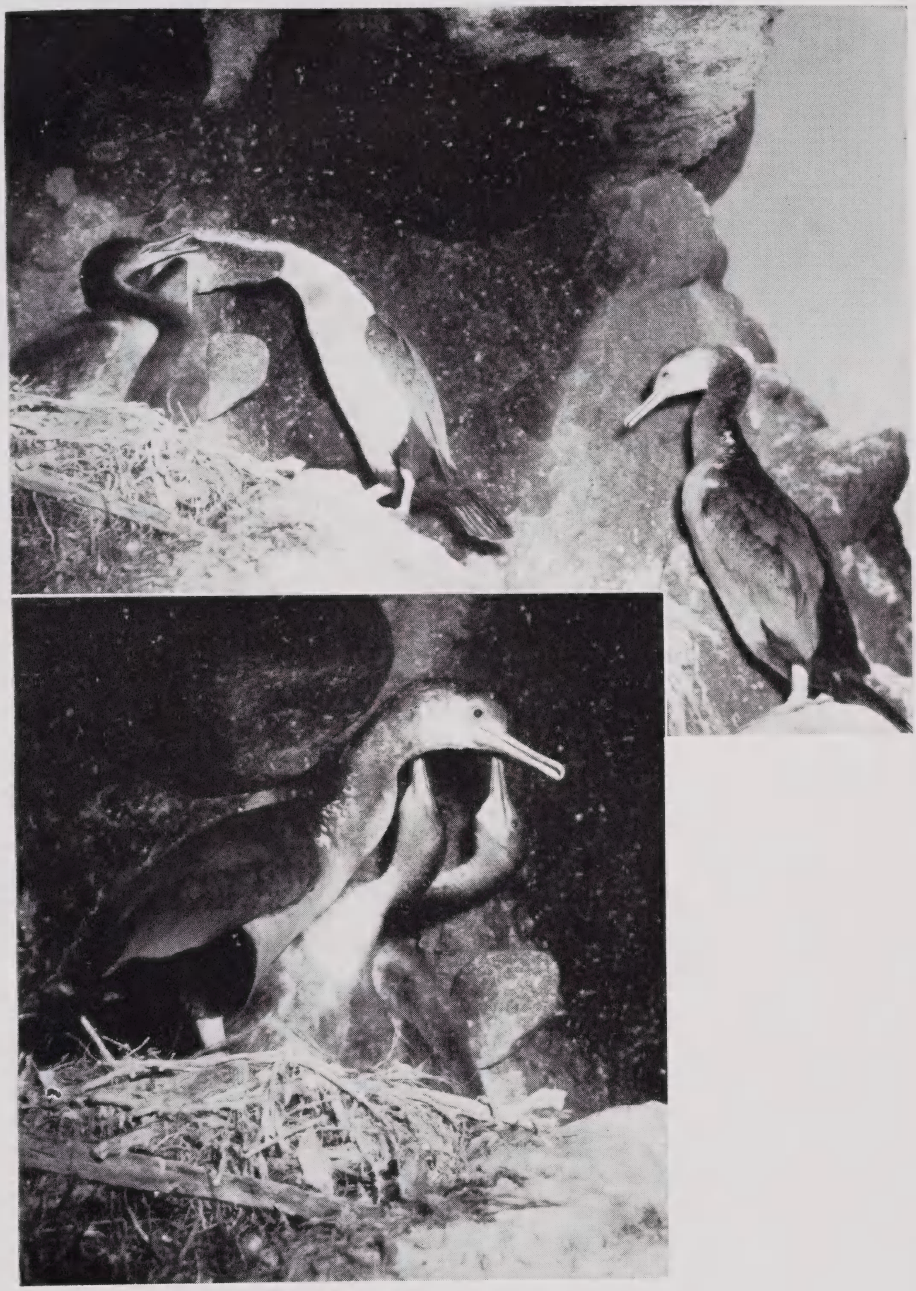

Fig. 6. *Post-nuptial plumage:* both adults at nest B, October, 1953, Bethells. The bird feeding a chick shows the more pronounced type of head pattern, and there are still a number of black feathers amongst the new grey and white on the throat (shown in nuptial plumage in Fig. 2).

Fig. 7. *Post-nuptial plumage:* "greyer" type of adult with chicks approximately four weeks old, nest B, October, 1953. (Shown in nuptial plumage in Fig. 3.)

Photos: O. Petersen.

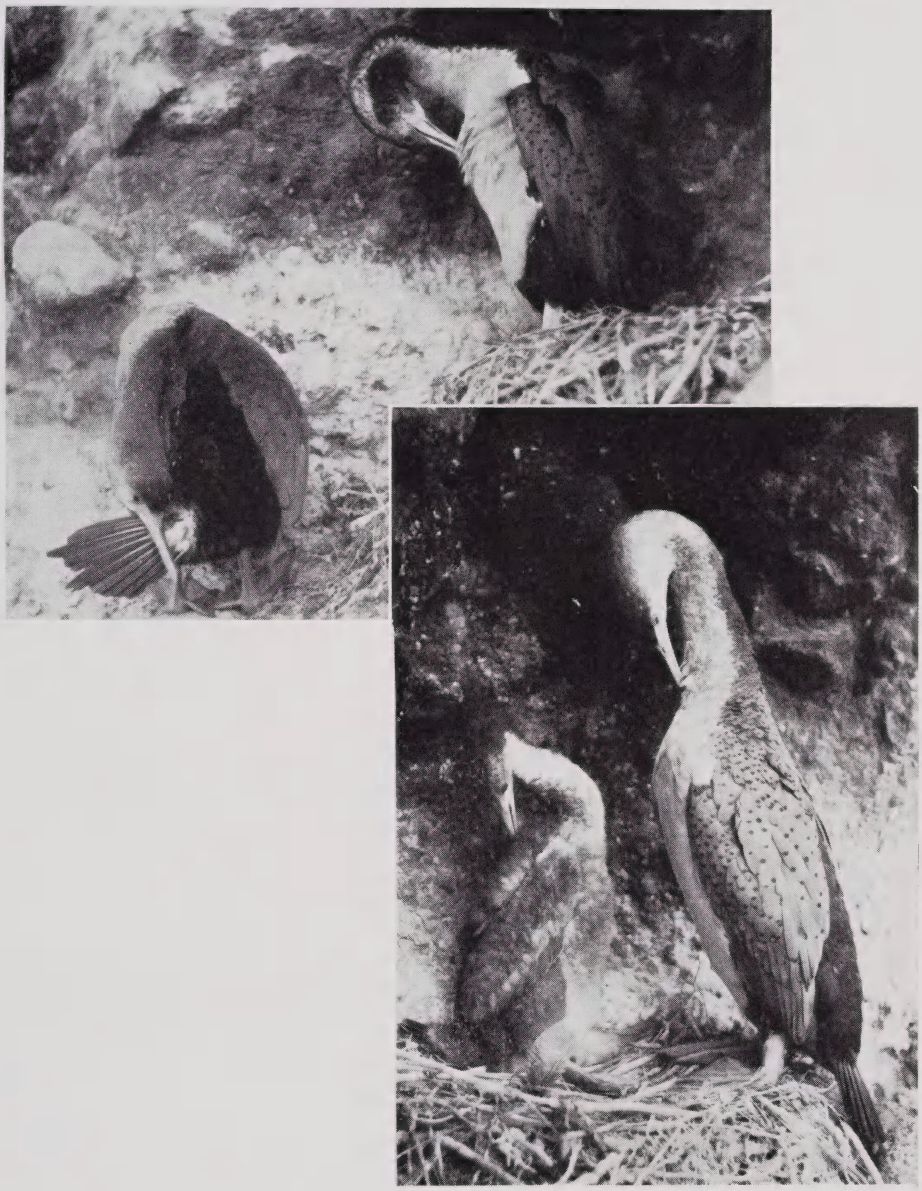

Fig. 8. *Post-nuptial plumage:* pair at nest A, November, 1952, Bethells. The single chick is partly hidden by the upper bird.

Fig. 9. *Post-nuptial plumage:* the lower bird in Fig. 8 (see above), showing the "greyer" type of plumage. The head pattern is indistinct and a few black feathers remain on the throat. Chick three to four weeks old showing first down partly replaced by the second. November, 1952.

Photos: O. Petersen.

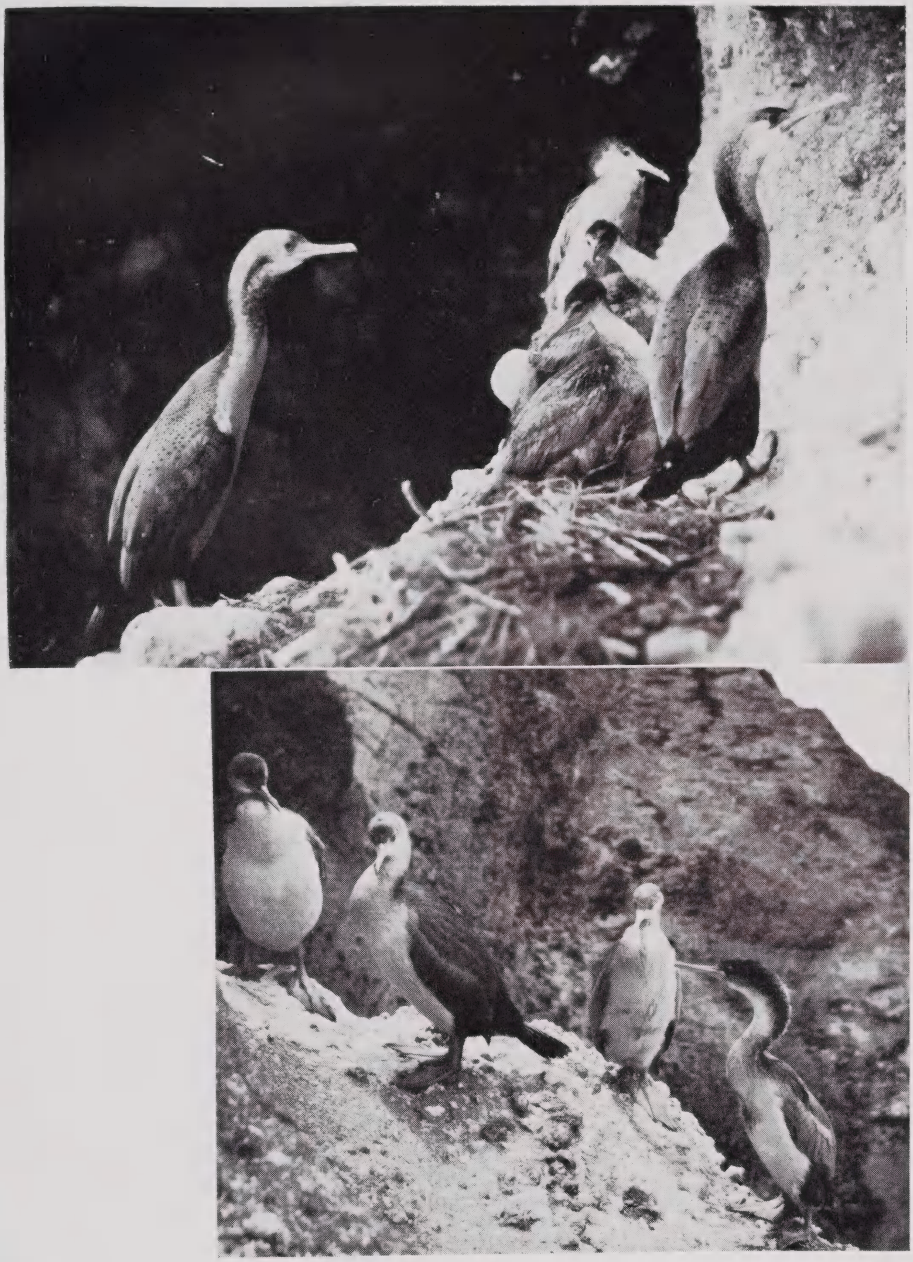

Fig. 10. Pair in post-nuptial plumage (left and right) and three fledglings (centre), still showing the second down on head and neck. The fledglings are between five and six weeks old. Nest C, November, 1954, Bethells.

Fig. 11. *Juvenal plumage:* (right) two young from nest C approximately seven weeks old on ledge near the nest, and (left) two juvenals just over nine weeks old. The young fly at nine weeks. December, 1954, Bethells

Photos: O. Petersen.